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Agricultural Memorandum No 482

Autumn Work Days. - Model II

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1. Model I - Ag.Mem 481, a first approach to the development of a physical model for autumn work days involved, in varying degrees, some of the processes that are important for the soil moisture balance.

   Since reservations were expressed by people of various disciplines with an interest in the topic, the work now reported represents an attempt to take note of comments about the data and procedure first employed.

2. Again we define an Autumn Work Day as one on which normal field working carries only a slight risk of structural damage to the soil; field work again is restricted to the primary cultivations (soil movement) intended for autumn sowing of crops.

   We assume the risk of structural damage before a return to field capacity is minimal and again concern ourselves with the risk after this time.

3. Model II. looks at various depths of soil, assumes that structural damage will occur if work goes ahead when the layers nominated contain water in excess of that which can be held at field capacity, and examines the consequences of 'drainage' times of varying length.

   The 'drainage' time used is considered to include an element for the duration of rainfall, the assumption being that with the soil at field capacity, any rain introduces an excess. We become concerned with initial start to the rain and the time after cessation of rain that the excess soil moisture (and in effect a 'drying front') takes to move down the profile.

   The assumption that any rain introduces an excess above field capacity in the surface layers is perhaps justified in a study which examines simply the average state and the average num ber of work days. In any simulation study which sought to indicate the range of work days about the seasonal or monthly average, such an assumption would not be justified and we would need to know the interval between raindays in order to assess the soil moisture deficit generated in the top few cms. by evaporation.

   The average daily potential transpiration appropriate to the month being studied is assumed to set a lower limit to the daily rainfall amount of which note need be taken.

   The depth of soil being examined leads to a value (20% by volume for all soils) of the rainfall amount that can readily be taken up; this now sets the rainfall amount above which special considerations must be applied.

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The former assumption (Model I) that all water should pass down through the soil is now replaced by one which allows surface run-off or sub-surface (horizontal) drainage above the sub-soil layer. These effects are are written in by limiting the number of work days lost, due to rainfall of any amount, to at most 2 days.

We assume that a start to rain is equally likely for each hour of the day.

We define a Work Day as one during which it is possible to achieve at least 5 hours continuous work (ie a full morning or a full afternoon) during a possible work day of 9 hours set centrally between sunrise and sunset. /When a maximum of 8 hours daylight is available as in December and January, the requirement for 5 continuous hours of work is retained/

In September for example with 13 hours of daylight, we may show that rain that takes 5 hours to remove, interferes with work on the day on which it falls (or on the subsequent day) on (5/24) % of occasions.

Rain that takes 10 hours to remove interferes with work on (11/24) % Of days.

Rain that takes 15 hours to remove interferes with work on (16/24) % of days.

Rain that takes 20 hours to remove interferes with work on(21/24) % of days.

Rain that takes 25 hours to remove interferes with work on 1 day on (23/24) % of occasions and with work on 2 day on (1/24) % of occasions.

Similar probability tables can be built up for other rain periods and other months. The relevant details used in this work are brought together in Tables.

Table I

Probability of interference with a Work Day for rainfall (+ drainage) times of various durations.

Rainfall (+ drainage) time		1 hr	3	5	10	15	20	25	30	35	40 hr
September) March)	Daylength 13 hours	1/24	3/24	5/24	11/24	16/24	21/24	25/24	30/24	35/24	40/24
October	Daylength 11 hours	1/24	3/24	5/24	11/24	15/24	20/24	25/24	30/24	35/24	40/24
November) February)	Daylength 9 hours	1/24	3/24	5/24	10/24	15/24	20/24	25/24	30/24	35/24	40/24
December) January)	Daylength 8 hours	2/24	4/24	6/24	11/24	16/24	21/24	26/24	31/24	36/24	41/24

4. A typical calculation is now carried through for the month of September at Cambridge.

Average daily potential transpiration = .065 ins (1.65) mm.
Days with rainfall in the period 1916-1950 (in September) .065 ins= 290

Depth of soil = 10 cms
Rainfall for 'saturation' of this layer= 20% of 10cms = 20mm = .79 ins
Days with rainfall in the period 1916-1950 (in September) .79 = 14.

We assume that on these 14 high rainfall days, with rainfall (+ drainage) times up to 10 hours (approx $\frac{1}{2}$ day), that work is interfered with on 1 day only.
For rainfall (+ drainage) times of 15 hours or more, work is interfered with on 2 consecutive days.

Rain + Drainage time = 1 hour

Days when work is interfered with = (290-14)(1/24) = 11
\+ 14 (1) = 14
Total 25

Average Work Days lost = 25/35 = 1
Average Work Days = 29

Rain + Drainage time = 3 hours

Days when work is interfered with = (290 -14)(3/24) = 34.5
\+ 14 (1) = 14
Total 48.5

Average Work Days lost = 48.5/35 = 2
Average Work Days = 28

Rain + Drainage time = 5 hours

Days when work is interfered with = (290-14)(5/24) = 57
\+ 14 (1) = 14
Total 71

Average Work Days lost = 71/35 = 2
Average Work Days = 28

Rain + Drainage time = 10 hours

Days when work is interfered with = (290-14)(11/24) = 127
\+ 14 (1) = 14
Total 141

Average Work Days lost = 141/35 = 4
Average Work Days = 26

Rain + Drainage time = 15 hours

Days when work is interfered with = (290-14)(16/24) = 184
\+ 14 (2) = 28
Total 212

Average Work Days lost = 212/35 = 6
Average Work Days = 24

etc. for longer Rain + Drainage times

The results for Cambridge rainfall, for various soil depth and for the months of interest are brought together in Table 2.

Table 2

Autumn (& Spring) Work Days - Cambridge data - Model II

Depth of soil considered - 5 cms

Rain + Drainage time	1 hour	3	5	10	15	20	25	30	35	40 hour
September	28	27	27	25	22	21	20	18	17	15
October	29	28	27	25	22	20	18	16	14	12
November	28	27	25	23	18	16	13	10	7	4
December	29	27	26	23	20	17	14	11	8	5
January	28	27	26	23	19	16	12	9	6	3
February	27	26	25	23	20	19	17	15	13	11
March	30	29	29	27	25	24	23	22	22	20

Depth of soil considered - 10 cms

Rain + Drainage time	1 hour	3	5	10	15	20	25	30	35	40 hour
September	29	28	28	25	24	22	21	19	18	16
October	30	29	28	25	23	21	19	17	14	12
November	29	28	26	23	20	17	14	11	8	5
December	29	28	27	24	21	17	14	11	8	5
January	29	28	26	23	20	16	13	10	6	3
February	27	26	25	23	21	19	17	15	13	11
March	30	30	29	28	26	25	24	22	21	20

Depth of soil considered - 15 cms

Rain + Drainage time	1 hour	3	5	10	15	20	25	30	35	40 hour
September	29	29	28	26	24	22	21	19	17	16
October	30	29	28	25	24	21	19	17	14	12
November	29	28	26	23	20	17	14	11	8	5
December	29	28	27	24	21	18	14	11	8	5
January	29	28	27	23	20	17	13	10	7	3
February	27	26	25	23	21	19	17	15	13	11
March	30	30	29	28	26	25	24	22	21	20

Depth of soil considered - 20 cms

Rain+ Drainage time	1 hour	3	5	10	15	20	25	30	35	40 hour
September	29	29	28	26	24	22	21	19	17	16
October	30	29	28	25	24	21	19	17	14	12
November	29	28	26	23	20	17	14	11	8	5
December	29	28	27	24	21	18	14	11	8	5
January	29	28	27	23	20	17	13	10	7	3
February	27	26	25	23	21	19	17	15	13	11
March	30	30	29	28	26	25	24	22	21	20

5. We come now to the interpretation of Table 2 and the allocation of various 'drainage' times to particular soil types.

With the emphasis on 'drainage' times, we notes that the depth of soil considered is now no longer important in its own right; soil depth is implicit in the 'drainage' times.

The first quantity to consider must be the duration of rainfall element of the 'drainage' times.

Duration of rainfall is a parameter about which the Meteorological Office is not very forthcoming. Data is available provided one is prepared to count from the original rainfall recorder records. Facilities to do this are not available at Meteorological Office, Cambridge and an average figure of about 4 hours has been obtained for the rainfall amounts of interest by an indirect method.

With an average rainfall element of the order 4 hours, a rain and drainage time of the order 5 hours suggests itself as the first possibility in Table 2 for the work days available on a light soil. 10 hours would seem a little too long for a light soil.

We suggest the range 10 hours - 15 hours rain + drainage time might therefore be appropriate to medium soils.

For heavy soils the range 20 hours - 40 hours rain + drainage time (approximately 1-2 days) would seem most appropriate. In view of the wide range of work days now appearing for the heavy soils, the suggestion is made that it might be convenient to consider rain + drainage times of 20 hours - 25 hours as appropriate to well drained heavy land and 30 hours - 40 hours as appropriate to undrained heavy land. The work day advantage of well drained heavy land now becomes of considerable interest.

6. As before, com ments and suggestions for improvement of the Model are welcome.

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